ANNOTATION

Doctor of Philosophy (PhD) dissertations in the field of 6D073100 - Occupational Safety and Environmental Protection (by branches)

Uakhitova Bagdagul Tuleuovna

Improving the level of occupational safety based on developed criteria for professional selection of personnel in hazardous professions of ferroalloy plants

The current state of the solved scientific problem.

Industrial injuries (hereinafter referred to as PT), as a result of accidents and accidents at industrial enterprises, is one of the urgent problems in all countries of the world.

According to the International Labor Organization (ILO), more than 2 million people die a year, which is almost 5% of the total mortality rate on the planet, 270 million people are injured, 160 million people suffer from various diseases related to production. In the Republic of Kazakhstan, 177 accidents occurred in the mining and metallurgical industry in 2015, which exceeds the figures of 2014 by 11%, including 20 fatal cases and 67 severe cases.

To date, the level of PT in Kazakhstan, as one of the CIS countries, is an order of magnitude higher than similar indicators in countries such as the UK, Germany, Canada, Japan, and the level of fatal injuries at work in our country is 2.5 times higher than in the USA, 7 times higher than in Japan, 8.7 times - than in England. Occupational injuries pose a serious danger to the health and life of people, especially workers of hazardous production facilities. Enterprises of the metallurgical industry, characterized by a high level of mechanization and automation of technological processes of production, are distinguished by a significant level of indicators of the danger of industrial injuries. In the Republic of Kazakhstan, this industry is currently one of the most traumatic.

The relevance of the problem

In the metallurgical industries, in the ferrous metallurgy of the Republic of Kazakhstan, there is a high level of injuries, in some cases fatal, throughout the entire existence of this corporation. Thus, in JSC TNK «Kazchrome» since 1991, an average of 24-25 accidents occur annually, including fatal ones. In this regard, the task of developing methods of preventive protection of workers from accidents and reliable prediction of the likelihood of injury at enterprises is relevant.

Practice shows that one of the main causes of injuries and accidents at work are shortcomings in the organization of work, erroneous actions of workers and IT. That is, the reason lies in the person himself, the so-called «human factor». Both his own safety and the safety of the personnel working next to him depend on the psychological stability of the employee. When using an integrated approach to predicting injuries, taking into account the psychological stability of production personnel, it is possible to significantly reduce injuries at the enterprise and improve occupational safety, because psychological stability is the reserve that is currently not fully applied in practice. Therefore, research in the field of recruitment for dangerous

professions, taking into account the psychological stability of employees, is certainly relevant.

The aim of the dissertation research: to enhance the level of occupational safety through the professional selection of personnel by means of psychological testing of workers in hazardous professions of ferroalloy plants. The reduction of injuries is achieved by determining the psychological resilience of the workers necessary for working in hazardous industrial facilities.

Research objectives:

- Analysis of the current state of injury assessment and the influence of psychophysiological qualities of workers on the level of injury in the ferrous metallurgy industry;
- Study of the state and indicators of occupational injuries in the structural units of industrial enterprises, taking into account the degree and impact of complex factors on accident rates, based on the statistical data of the Aktobe Ferroalloy Plant;
- Selection and justification of a methodology for qualitative assessment of the functional state of metallurgical workers for the occupational safety and health service, aiming to select performers for hot workshops in the ferroalloy production plant, with the goal of reducing the overall level of injuries based on a preliminary evaluation of performers considering the "human factor";
- Investigation of the dangers of injuries and the state of occupational safety in the melting workshops of the Aktobe Ferroalloy Plant, using quantitative risk assessment methods;
- Development of a mathematical model for predicting the probability of occupational injuries to develop preventive measures.

Research Methods:

During the research work, an analysis of injuries at the Aktobe ferroalloy plant in the period from 2012 to 2020 was carried out using the statistical method.

A quantitative assessment of the risk of hazards at the gas station of JSC TNK Kazchrome was carried out using the Kinney method based on statistical data for the period from 2012 to 2020.

The regularities for the main indicators of injuries have been determined, according to the statistical method of research over the years by using the Microsoft Office Excel program using the least squares polynomial regression method.

Psychological testing in order to identify employees prone to injury ("traumatics") was carried out according to the proposed methodology.

When developing a technique for short-term injury prediction, a Poisson probability distribution was used and the program was compiled using the Delfu programming language.

Key findings (validated scientific hypotheses and other conclusions representing new knowledge) presented for defense:

- The most hazardous workshops in the ferroalloy production (using the Aktobe Ferroalloy Plant as an example) are the melting workshops, and among the professions within these workshops, melters and repair fitters have the highest injury rates, accounting for approximately half (47%) of all reported injuries at the plant during the study period;

- Nonlinear polynomial relationships of the fourth degree have been determined between the severity coefficient, frequency, mortality rate, overall injury rate, and the study period;

- The number of workers in hazardous professions, referred to as «injury-prone» or individuals predisposed to injuries based on their personal qualities, has been identified in the melting workshops № 1, 2, and 4 of the Aktobe Ferroalloy Plant. According to the conducted psychological testing, the proportion of "injury-prone" individuals accounted for 12.4% of the total number of tested workers in hazardous professions within these workshops;

- The effectiveness of implementing psychological testing methodology to reduce the level of injuries among workers in hazardous professions in the melting workshops, considering the «human factor,» averaged at 33.4% (Appendices G and E);

- The mathematical model for short-term (1-2 year) injury forecasting based on the Poisson probability distribution, implemented in the Delfy programming language, has a forecast accuracy for the Aktobe Ferroalloy Plant of no less than 90%.

Description of the main research results.

The following key results were obtained from the conducted research:

- The main causes and factors of injuries, hazardous workshops at the plant, as well as injury patterns based on parameters (frequency coefficients, severity, overall injury rate, etc.), age, and work experience of the plant's workers during the study period (2012-2020) were identified. These patterns are characteristic of ferroalloy plants in the metallurgical cluster;

- A methodology for psychological testing of workers in hazardous professions was developed and justified. The testing of workers in the melting workshops № 1, 2, and 4 revealed that, on average, 12.4% of workers have a predisposition to injuries based on the so-called «human factor». These results allow for the application of this methodology in other ferrous metallurgy enterprises in the Republic of Kazakhstan;

- Recommendations for the labor protection and industrial safety department of the Aktobe Ferroalloy Plant were developed and implemented in 2020. These recommendations resulted in an average reduction of 33.4% in the overall injury rate in the melting workshops based on injury data from 2020-2021 (Appendices A and B). Similar recommendations can be used in other ferrous metallurgy enterprises in the Republic of Kazakhstan;

- A mathematical model for short-term injury forecasting based on the Poisson probability distribution was developed. This model provides a 90% accuracy in predicting expected injuries. Reliable injury forecasting facilitates the implementation of effective preventive measures to reduce or prevent injuries.

The model for injury forecasting can be applied to all ferrous metallurgy enterprises in the Republic of Kazakhstan.

Justification of the novelty and importance of the obtained results.

Through the statistical analysis of injuries at the Aktobe Ferroalloy Plant, regularities were established, identifying professions with significantly higher injury rates compared to others. These professions include ferroalloy melters and repair

fitters, accounting for 9 cases (26,5%) and 7 cases (20,5%), respectively, of the total number of injuries during the study period;

In terms of age, the age group of 40-49 years had the highest susceptibility to injuries, with 9 cases (26,5%), followed by workers above 50 years with 8 cases (23,5%) of the total number of injuries during the study period;

Regarding work experience, workers with 1-2 years of experience had the highest injury rate with 9 cases (26,5%), followed by workers with 7-9 years of experience with 7 cases (20,5%) of the total number of injuries during the study period;

Nonlinear polynomial relationships of the fourth degree were derived using the least squares method for the distribution of injury indicators, including severity coefficients, frequency, mortality rate, and overall injury rate during the study period;

Based on the analysis of data from the conducted psychological testing, a predisposition to injuries was found on average in 12,4% of all tested workers in the melting workshops № 1, 2, and 4 of the Aktobe Ferroalloy Plant;

A mathematical model for short-term (1-2 year) injury forecasting was developed based on the Poisson probability distribution. The forecast accuracy of the proposed model for the Aktobe Ferroalloy Plant was at least 90%.

The scientific work was carried out in accordance with the direction of research on the approved research topic «Improving the level of labor safety based on the developed criteria for the professional selection of personnel for dangerous professions of ferroalloy workshops» at the Department of "Life Safety and Environmental Protection" of the M.Auezov South Kazakhstan University for 2018-2021.

Correspondence to scientific directions or state programs.

The work was carried out in accordance with the research direction of the Committee for Science of the Ministry of Education and Science of the Republic of Kazakhstan, specifically in the specialized scientific direction 9.2. Applied scientific research. 9.2.7 Research in the field of fire and industrial safety, civil defense, prevention, and elimination of natural and man-made emergencies.

Approbation of the results of the work, publications.

The main scientific results and recommendations of the scientific hypothesis have been published in 12 publications, including:

in the scientific journal "Izvestiya NAS RK" included in the Scopus database – 4 articles, in journals recommended by the Committee for Quality Assurance in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan – 1 article, in journals, in the materials of international conferences - 4 articles, articles in the materials of conferences of the Republic of Kazakhstan - 3, author's certificate No.31614 on "Mathematical model of injury prognosis in ferroalloy production", dated January 6, 2023.

Description of the doctoral candidate's contribution to the preparation of each publication. The doctoral candidate's overall contribution accounts for 55-60%. The contributions to the articles include conducting experimental research, processing the results into tabular values and graphical dependencies, and obtaining computational equations, development of a mathematical model.